



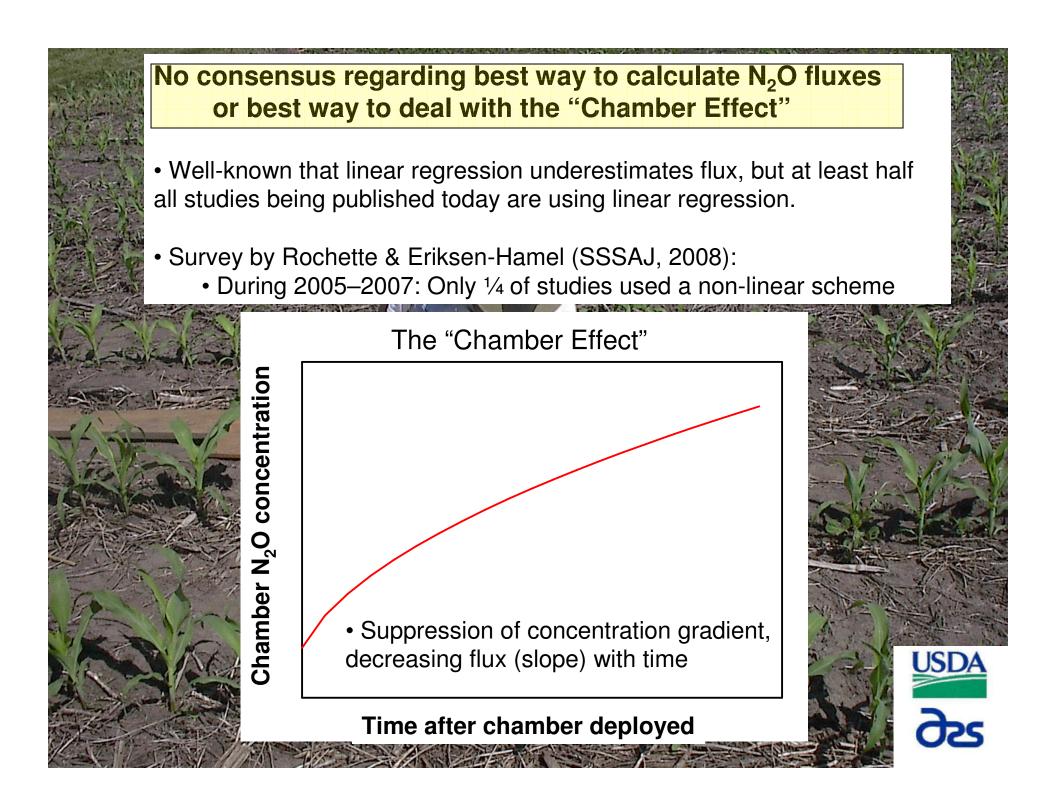
1. To evaluate the ACCURACY and PRECISION of the most commonly used methods for calculating N<sub>2</sub>O fluxes based on chamber data.

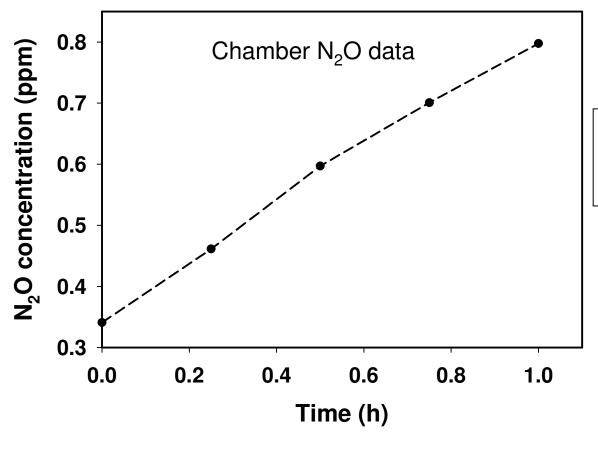
Venterea & Baker, 2008. SSSAJ.

- 2. To develop spreadsheet-based tools for quantifying ACCURACY & PRECISION under specific conditions. *Venterea et al., 2010. SSSAJ.*
- 3. To develop a simplified method for calculating fluxes that's based on fundamental gas transport theory. *Venterea. 2010. JEQ*

http://www.ars.usda.gov/

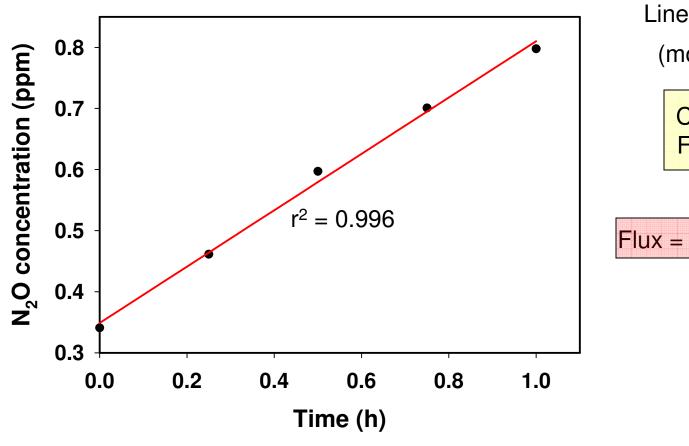


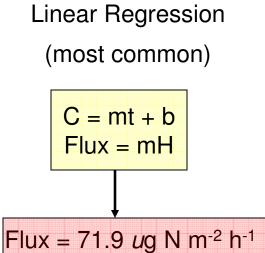




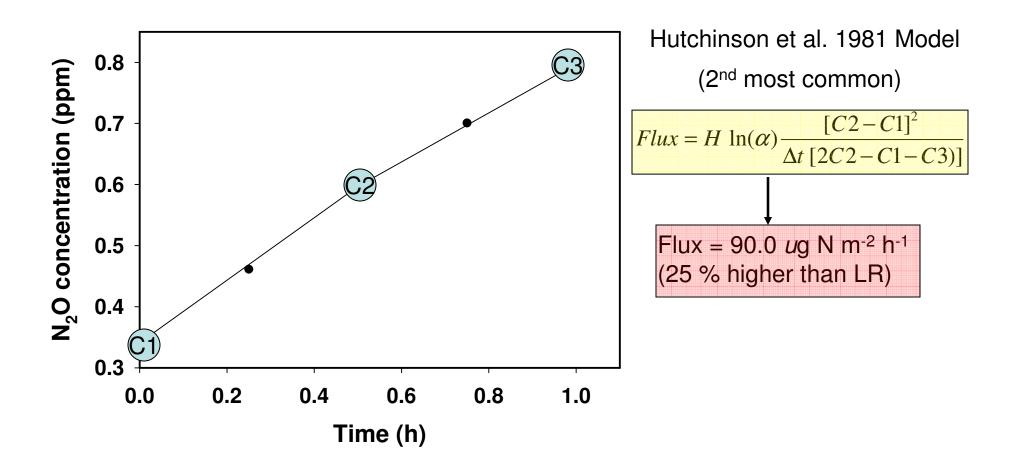
Volume:Area (H) = 13.44 cm Bulk density = 1.12 g cm<sup>-3</sup> Water content = 0.12 cm<sup>-3</sup> cm<sup>-3</sup>



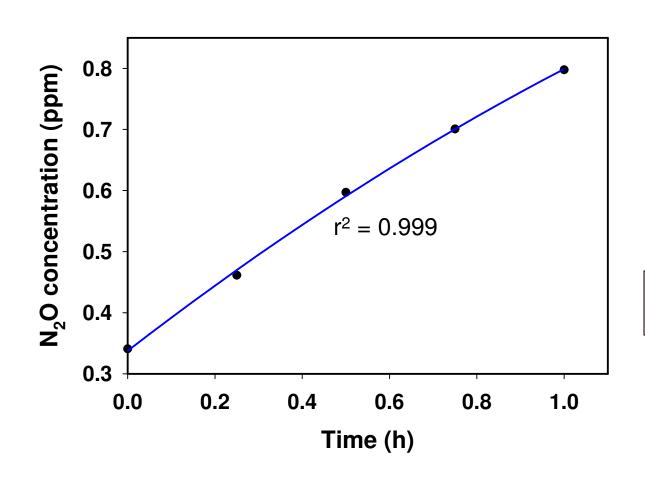






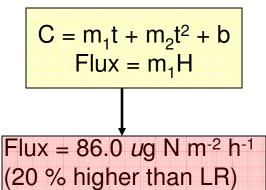




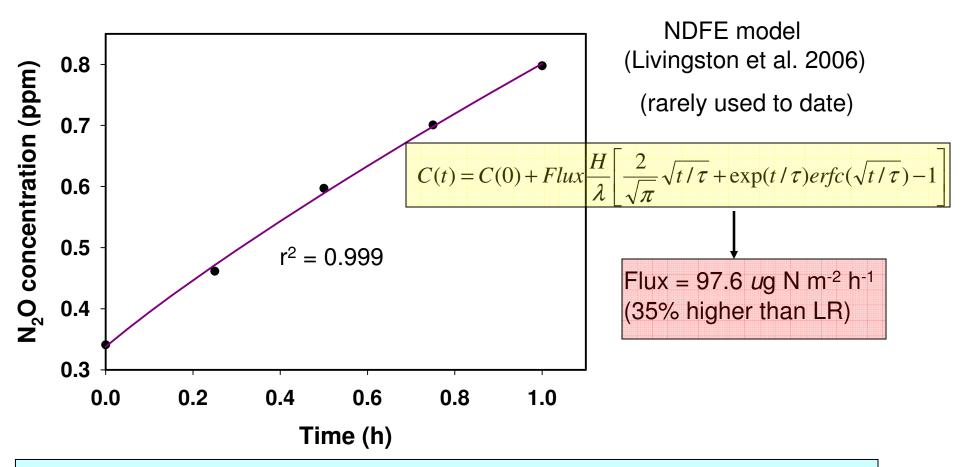


Quadratic Regression (Wagner et al. 1997)

(3<sup>rd</sup> most common)



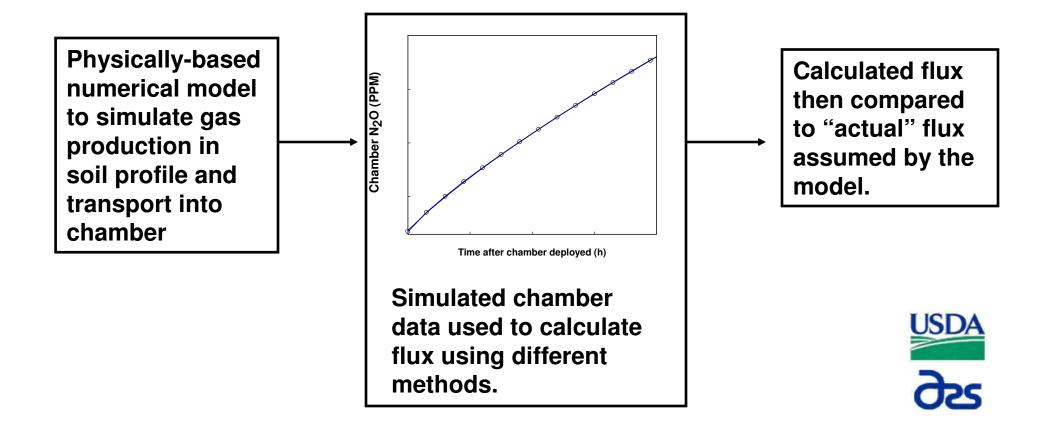




- 1. Goodness of fit (e.g. r<sup>2</sup> value) is not necessarily a good indicator of accuracy.
- 2. Calculation method can make a large difference in GHG esimates. Difference between high and low = 25.7  $ug N m^{-2} h^{-1} \approx 3 kg CO_2 ha^{-1} d^{-1}$

- No way to directly know what the pre-deployment flux is under field conditions.
- Lab studies to simulate field conditions: Linear regression underestimates flux.

**Numerical Modeling** Approach to Evaluate Accuracy (Hutchinson, Healey, Livingston et al)



### **Numerical Modeling** Approach to Evaluate Accuracy

$$S(z)\frac{\partial C_g}{\partial t} = \frac{d}{dz} \left( D(z) \frac{dC_g}{dz} \right) + P - S$$

Venterea and Baker, SSSAJ (2008), Venterea et al., SSSAJ (2009)

Key assumptions (less restrictive than previous models, e.g., Livingston et al. 2006):

- Gas transport is dominated by 1-D vertical diffusion Chamber has properly designed vent tube Sufficient chamber insertion depth
- 2. Chamber headspace gas is uniformly mixed
- 3. No transformation or leakage of N<sub>2</sub>O in the chamber

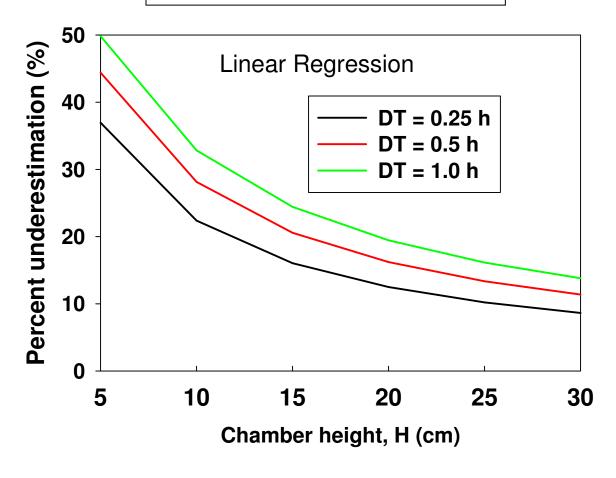
Assumptions may not always hold: Results are valid only under these conditions.



Developed spreadsheet-based method for quantifying errors in flux estimates

Chamber errors increase with:

- Smaller chamber heights (H)
- Longer deployment times (DT)

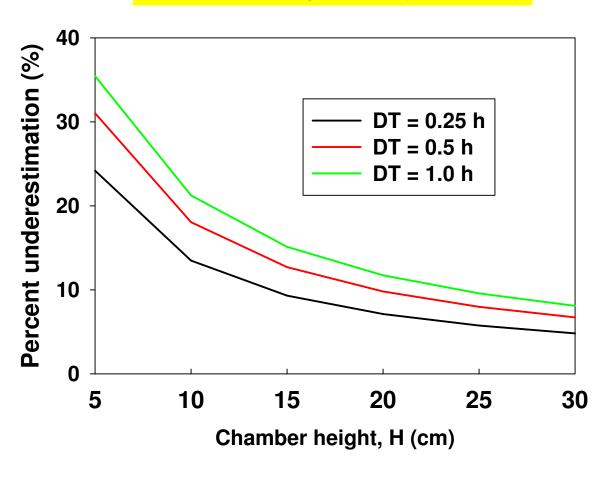




Even non-linear FC schemes will underestimate flux.

Model of Hutchinson and Mosier (1981)

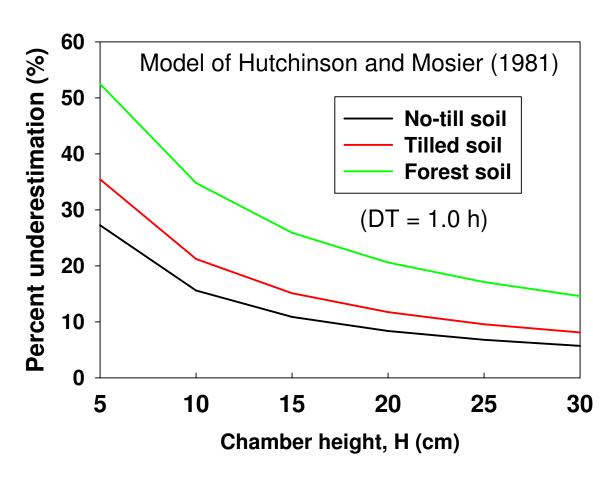
≈ Quadratic Regression (with 1-2%)





Chamber effect is greater in more porous soils

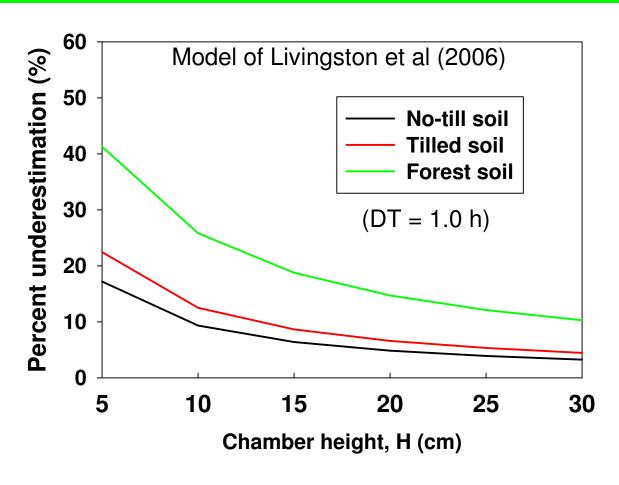
Can lead to biases in evaluating treatment effects





Even the NDFE model can under-estimate flux (if soils are not physically uniform)

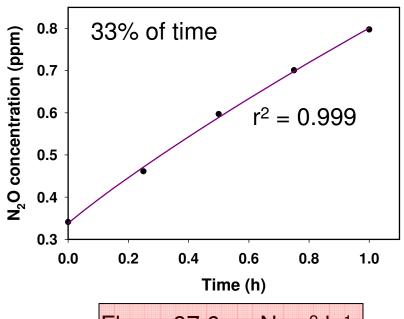
#### NDFE is generally most accurate at a given H, DT, and soil type



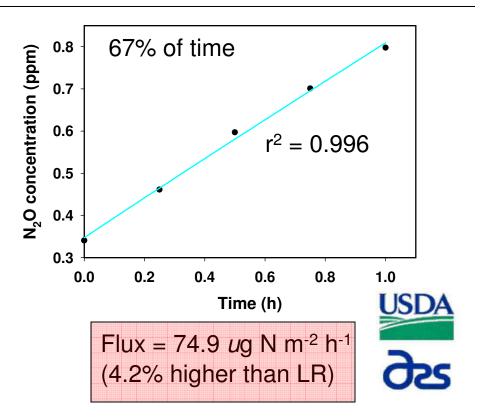


#### NDFE commonly returns more than one flux value for a given chamber data set

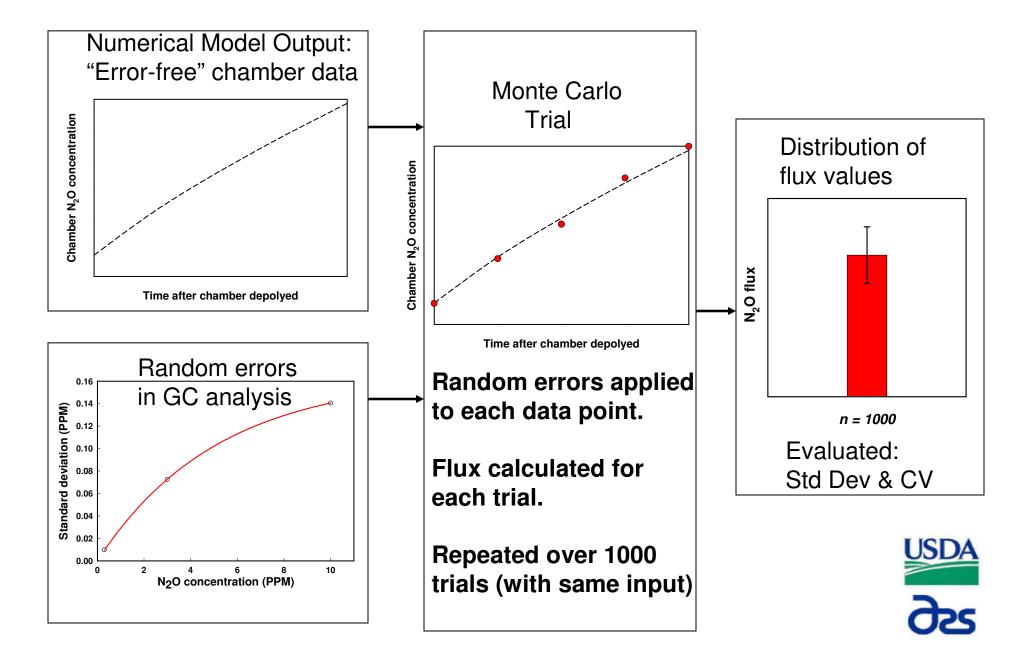
- Uses non-linear regression, solves for 3 parameters (one is the flux)
- Multiple runs of solver usually yields two or three values (w/actual and modeled)
- Uncertainty in criteria for selecting "correct" value
- Ranked low in the precision category.



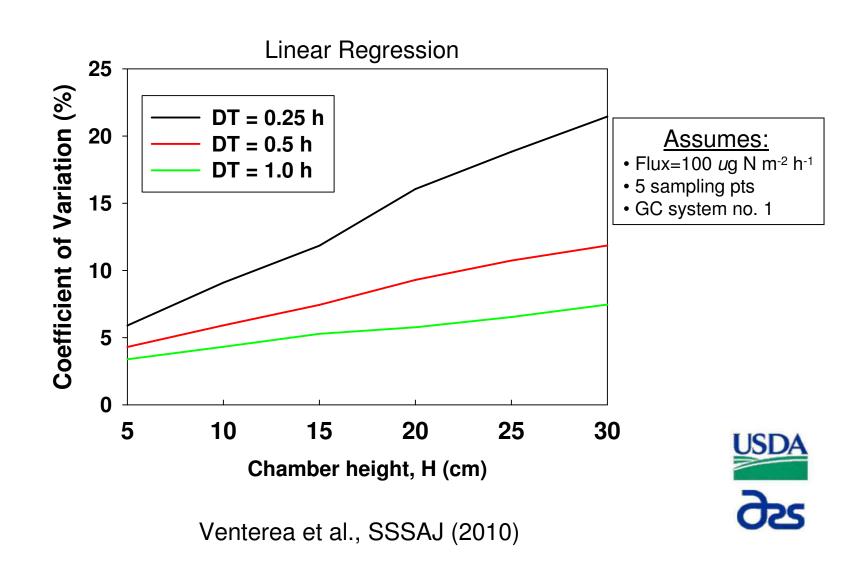
Flux = 97.6 *u*g N m<sup>-2</sup> h<sup>-1</sup> (35% higher than LR)



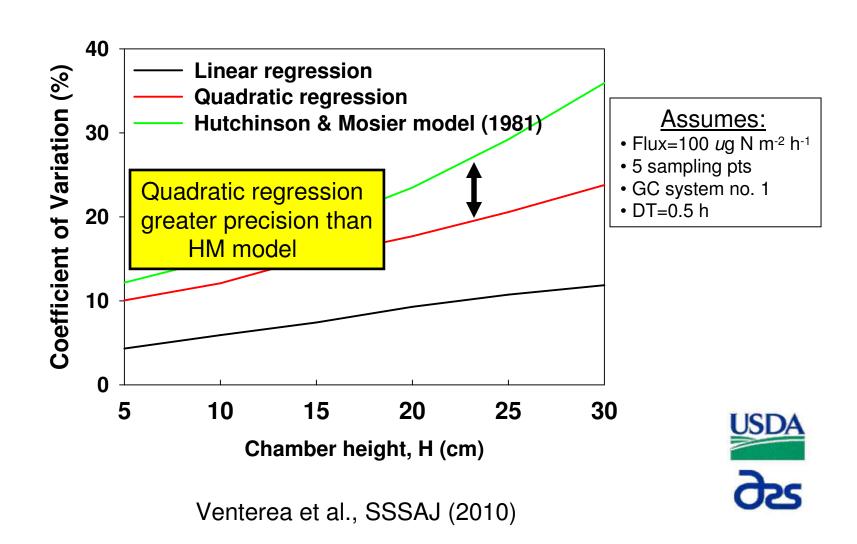
# **Precision** Monte Carlo Analysis



Dilemma no. 1: Increased chamber height (H) or reduced deployment time (DT) increase accuracy but reduce precision depending on extent of random error.

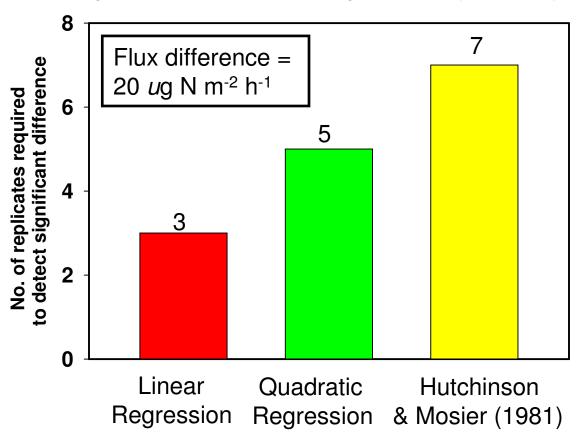


Dilemma no. 2: Using a non-linear FC scheme increases accuracy but reduces precision of flux estimate compared to linear regression



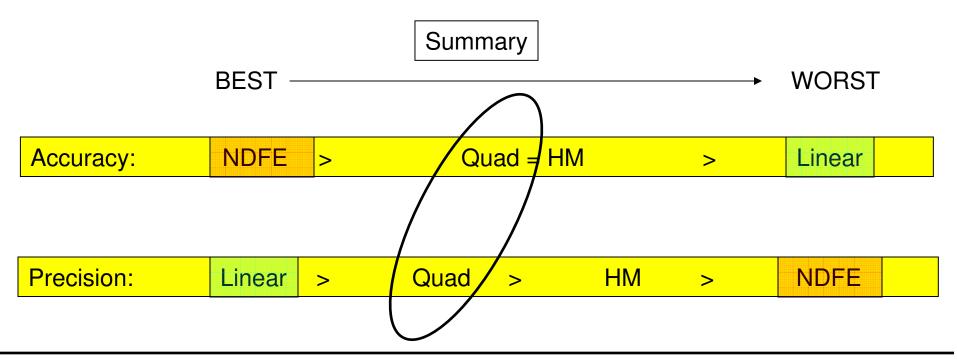
Dilemma no. 2: Linear regression is more sensitive to detecting differences than non-linear calculation methods.

Number of Monte Carlo replicates required to detect a significant difference using ANOVA (P < 0.05).





Venterea et al., SSSAJ (2010)



- No optimum method.
- If interested mainly in comparing among treatments, linear regression best.
- In this case, also include error analysis to estimate absolute magnitude of fluxes.
- Quadratic regression may be the best balance between accuracy and precision.



#### Alternative method

Venterea. 2010. JEQ. Simplified Method for Quantifying Theoretical Underestimation of Chamber-Based Trace Gas Fluxes

- Based on same theory as NDFE method
- Similar accuracy with both actual & modeled
- Returns single value, and uses no macros
- Uses results of linear or quadratic, adjustments to account for chamber effect
- Might be more balanced in terms of accuracy and precision
- Possible drawback: Requires measurements of bulk density and water content
- Precision of soil measurements will enter into overall precision



#### **Concluding remarks**

- Chamber methods vary greatly among studies. This leads to greatly different errors in estimating N<sub>2</sub>O fluxes.
- We compared percent flux underestimation in 6 different studies published in 2008 and 2009: ranged from < 10% to > 30%.
- Any efforts to develop accurate N<sub>2</sub>O emissions inventories are going to be hindered by the diversity of methods unless we come to some consensus.
- Also has implications for model development, since models can only be calibrated using actual data.

